PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

TAKAGUCHI et al

Application No.: 10/573,449 Art Unit: 1793

Filing date: January 19, 2007 Examiner: Megha Mehta

For: WAVE SOLDERING TANK

SUBMISSION OF DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In support of the amendment filed on August 16, 2010 in connection with the present application, a declaration under 37 CFR 1.132 is attached.

The declaration is by Professor Charles Garris of the Department of Mechanical and Aerospace Engineering at The George Washington University. Professor Garris has a degree in marine engineering, he has done considerable research in the field of fluid flow, and he teaches, among various courses at The George Washington University, a class in the design of turbomachinery such as pumps, compressors, and turbines. As such, Professor

Garris is highly conversant with the design of axial flow pumps such as screw pumps.

As set forth on page 2 of the declaration, increasing the number of blades in a screw pump has both advantages and drawbacks. Increasing the number of blades can increase the effectiveness of flow induction by increasing the contact area between the blades and the working fluid. At the same time, increasing the contact area can negatively affect flow induction due to increased energy dissipation by increased blockage of flow passages. Therefore, as stated on page 2 of the declaration, in a given application, it is difficult to predict the number of blades and the optimal number of helix turns for optimal flow induction without performing extensive experimentation.

Pages 3 and 4 of the declaration describe the flow induction efficiency of a screw pump. As stated on page 4, providing a pump with a larger number of blades and/or a larger number of turns can potentially increase the stability of fluid and decrease pressure fluctuations, but it is not readily predictable whether the beneficial effects of an increased number of blades and an increased number of turns on stability and a decrease in pressure fluctuations will outweigh the beneficial effects of a reduced number of blades and fewer turns.

Pages 4 - 6 of the declaration review the two references which were cited in the most recent official action, i.e., JP 62-

259665 (referred to in the declaration as JP '665) and U.S. Patent No. 7,165,933 (referred to in the declaration as Gerstenberg) and discusses what teachings of Gerstenberg would be considered to be relevant to the disclosure of JP '665 by a designer of turbomachinery.

As stated on page 4 of the declaration, Gerstenberg discloses a screw pump for transporting highly viscous emulsions that are widely used in the food industry. Gerstenberg states that the pump may have one or more screw blades on a rotor, and the preferred number of screw blades is in the range of 1 - 10, preferably 1 - 6, and more preferably 2 - 5. However, as set forth on page 5 of the declaration, there is nothing in the description of Gerstenberg that ties any benefits of its screw pump to the number of blades on the rotor. Therefore, there is no disclosure in Gerstenberg that would tell a designer of turbomachinery that employing a certain number of blades, such as 2 - 5 blades, is necessarily related to accomplishment of the goals of Gerstenberg.

For this reason, as set forth on page 5 of the declaration, the fact that Gerstenberg recommends a screw pump having at least 2 blades would not tell Professor Garris, who is a person with significant experience in the design of turbomachinery, that such a pump would be suitable for the pump shown in JP '665.

Firstly, as set forth on page 5 of the declaration, even if

it is assumed that employing at least 2 blades in Gerstenberg is related to maintaining a uniform pressure and temperature of the material being pumped, these are not issues that would be important in the pump shown in JP '665.

Secondly, as stated on page 5 of the declaration, there is no teaching about pumping efficiency in Gerstenberg. Thirdly, the optimal number of blades from the standpoint of pumping efficiency is entirely different for a highly viscous fluid such as a food emulsion and for a much less viscous fluid, such as molten solder. As stated on page 6 of the declaration, the emulsions being handled in Gerstenberg are far more viscous than is the molten solder being handled by the pump shown in JP '665. In light of this huge difference in viscosity, it does not follow, from the standpoint of a designer of impellers, that changing the pump of JP '665 from a single-blade pump to a multiple-blade pump would necessarily provide any improvement in performance.

Pages 6 and 7 of the declaration review experimental data provided by the inventors which shows the height of a solder wave produced by a two-blade screw pump and a four-blade screw pump (Exhibit A), as well as experimental data showing the change in the height of a solder wave in response to a step change in the operating speed of a one-blade screw pump or a four-blade screw pump (Exhibit B).

Exhibit A shows that at a given pump rpm, a greater wave height was produced by a four-blade pump than for a two-blade pump, although the difference substantially disappeared as the rotational speed increased.

Exhibit B shows that when the rotational speed of a one-blade pump or a four-blade pump was instantaneously changed, the four-blade pump stabilized at a new wave height much more rapidly than did the single-blade pump. As set forth on page 7 of the declaration, this result is not predictable, since Professor Garris does not know of any characteristic of screw pumps which would necessarily result in this phenomenon.

In summary, the declaration shows that from the standpoint of a designer of turbomachinery, there is no predictable benefit to increasing the number of blades of a screw-pump for a wave soldering tank. In particular, a designer of turbomachinery could not predict from the disclosure of Gerstenberg the result of increasing the number of blades in the screw pump of JP '665, and the results shown in Exhibit B of the declaration are unexpected.

Favorable consideration is respectfully requested.

Respectfully submitted,

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In re application of:

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Application No.: 10/573,449 Art Unit: 1793

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For: WAVE SOLDERING TANK

DECLARATION UNDER 37 CFR 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Charles Garris, declare as follows:

I am a Professor of Mechanical and Aerospace Engineering at the George Washington University in Washington, DC. I teach courses in, among other areas, turbomachinery, energy conversion and mechanical design.

I have an undergraduate degree in Marine Engineering from the State University of New York, Maritime College, and a Ph.D. in Mechanical Engineering (1971) from the State University of New York at Stony Brook. I am a Registered Professional Engineer in the State of Virginia. I am also a Registered Patent Agent qualified to practice before the USPTO.

I am a Fellow of the American Society of Mechanical Engineers and an Associate Fellow

of the American Institute of Aeronautics and Astronautics. I am also the recipient of the 2006 Thomas A. Edison Patent Award from the American Society of Mechanical Engineers. In addition, I am the director and founder of the GWU Propulsion Laboratory in Washington, DC.

One of the courses that I regularly teach at George Washington University is turbomachinery. This course includes the design of pumps, compressors, and turbines. Both liquid and gaseous working fluids are studied. Of particular importance in the design of axial flow turbomachines is the determination of an optimal number of blades.

The blades of propellers and fans are similar to a helix of a screw pump in that they all interact with a fluid in order to produce flow induction. Further, the all generally have a plurality of blades which extend helically around an axis and are intended to induct fluid in a direction parallel to the axis. The purpose of utilizing a multiplicity of blades is to increase contact between the energy imparting blade and the fluid in order to increase the contact area, and thereby the effectiveness of the flow induction. The contact area can also be increased by increasing the number of turns of the helix. However, increasing the contact area by either means can negatively affect the flow induction process because of the dissipation of energy through viscous interaction between the fluid and the vane. The greater the contact area, the greater the dissipation. Further, the presence of multiple vanes causes blockage of the flow passages due to the necessary vane thickness, which also reduces the effectiveness of the flow induction process. Thus, in a given application, it is difficult to predict the number of vanes, and the optimal number of helix turns, for optimal flow induction without extensive experimentation. Furthermore, there are other important characteristics of a pumping device that might be important for a given application such as dissipation of transients during start-up, uniformity of flow at discharge, absence of pulsations, and the like. All of these characteristics can be influenced by the number of vanes and the number of turns in ways that are difficult to predict.

COMPARISON OF SINGLE-BLADE PUMP AND MULTIPLE-BLADE PUMP

With certain working fluids, if one compares a single-blade screw impeller and a two-blade screw impeller having the same diameter and the same pitch of the blades, the two-blade screw impeller may transport either a larger volume or a smaller volume of fluid per rotation of the impeller than the single-blade impeller. With certain working fluids, a three-blade impeller may transport either a larger volume or a smaller volume of fluid per rotation of the impeller than a two-bladed impeller having the same diameter and pitch. Whether or not an increase in the number of blades improves or deteriorates performance is determined by two competing phenomena:

1. Because of the greater contact area between the blades and the fluid for a higher number of blades, the opportunity of the fluid to bypass the vane is reduced. This is by virtue of the increased vane surface which helps force the fluid to move in the desired direction.

2. This aforementioned beneficial effect is decreased by the detrimental effects of the increased viscous dissipation due to the increased blade-fluid contact, and the increased blockage.

As the number of blades increases, there is generally an optimal efficiency, beyond which flow induction efficiency decreases as the number of blades increases. For a given working fluid, the optimum number of blades can only be determined by experimentation.

If we define the flow induction efficiency of an impeller as:

$$\eta = Q\Delta P/P_{in}$$

where:

η = flow induction efficiency

Q = volumetric flow rate (m^3/s)

ΔP = pressure differential (Pa)

P_{in} = Electrical Power supplied to pump (w)

only experimentation will determine for a given working fluid when the flow induction efficiency is a maximum for a given rpm, number of vanes, and number of turns of the vanes, and for a given pressure drop and a given flow rate.

Providing a pump with a larger number of blades and/or a larger number of turns can potentially increase the stability of fluid and decrease pressure fluctuations. However, it is not readily predictable whether the beneficial effects of an increased number of vanes and an increased number of turns on stability and a decrease in pressure fluctuations are outweighed by the beneficial effects of a reduced number of vanes and fewer turns.

COMPARISON OF REFERENCES

I have reviewed the drawings and English abstract of Japanese Patent Document JP 62-259665 (referred to below as JP '665). I have also reviewed the specification and drawings of U.S. Patent No. 7,165,933 (referred to below as Gerstenberg).

JP '665 describes a solder tank 2 equipped with a spiral screw 23 which is rotated by a driving motor 33 to jet molten solder 8 from a jet nozzle 18. As can be seen from Figures 2 and 3 of JP '665, the spiral screw 23 has a single blade. The blade appears to extend around the spiral screw 23 for approximately two turns or 720 degrees.

Gerstenberg discloses a screw pump for transporting highly viscous emulsions that are widely used in the food industry. Column 3, lines 63 - 67 state that there may be one or more screw blades provided on a rotor, and it is preferred that the number of screw blades be in the range of 1 - 10, preferably 1 - 6, and more preferably 2 - 5. In the figure of Gerstenberg, a screw pump has two blades which appear to spiral around the pump for around one and a half turns, or around 540 degrees.

Gerstenberg does not say why the most preferred number of blades is 2 5. Gerstenberg says in column 2, lines 39 - 42 that a screw pump according to its invention has shown to be able to transport a viscous fluid in particular an emulsion in a gentle way without excessive influences of heat or pressure to the product. However, there is nothing in the description of Gerstenberg that ties these benefits to the number of blades on the rotor. Gerstenberg prevents excessive influences of temperature by providing a jacket 4 for supply or removal of heat surrounding a cylindrical housing 1. On the other hand, according to column 3, lines 31 - 34 of Gerstenberg, an excessive pressure increase or decrease is prevented by making the inner cross section of the cylindrical housing constant over its length. Accordingly, there is nothing in Gerstenberg that tells me, as a designer of turbomachinery, that employing a certain number of blades, such as 2 - 5 blades, is necessarily related to accomplishment of the goals of Gerstenberg.

As a person with significant experience in the design of turbomachinery, the fact that Gerstenberg recommends a screw pump having at least 2 blades would not tell me that a similar pump would be suitable for the pump shown in JP '665. Firstly, even if we assume that the fact that Gerstenberg employs at least 2 blades is somehow advantageous to maintaining a uniform pressure and temperature of the material being pumped (something that Gerstenberg does not actually state), this is not an issue at all in wave solder technology. Therefore, such a teaching, if it existed, would be entirely irrelevant for the invention of JP 62-259665.

Secondly, pumping efficiency is not an issue in Gerstenberg, and there is no teaching in this regard. Furthermore, the optimal number of blades for pumping efficiency for a highly viscous emulsion is entirely different than for a much less viscous solder. Gerstenberg emphasizes this fact in column 3, lines 17 - 18 where it says that "As the person skilled in the art will appreciate pumping of a fluid depends on the rheological properties of said fluid". In column 3, lines 19 - 22. Gerstenberg states that his pump is for use with emulsions having viscosities higher than 100 cP, preferably higher than 500 cP, and most preferably higher than

1000 cP. In contrast, typical solders have much lower viscosities. For example, according to Brazing and Soldering: Proceedings of the 3rd International Brazing and Soldering Conference, edited by John Stephens (ASM International, 2006), page 200, a near eutectic Pb-Sn solder has a viscosity μ of 2.7 mPa-sec, which corresponds to only 2.7 cP.

Therefore, from the standpoint of a designer of impellers, it does not follow that changing the pump of JP 62-259665 from a single-blade pump to a multiple-blade pump would necessarily provide any improvement in performance.

EXPERIMENTAL DATA

I have also reviewed the attached data, which shows the results of experiments performed by the applicants with a wave soldering tank having a single-blade screw pump or a multiple-blade screw pump. The figures show the wave height of a solder wave when the rotational speed of the pumps was set to different values.

These figures show that at a given rotational speed, a four-blade pump being tested produced a larger wave height than a single-blade or two-blade pump being tested. As stated above, a multiple-blade pump may or may not pump a larger volume of fluid per rotation of the pump than a single-blade pump having the same dimensions and operating at the same rotational speed. In EXHIBIT A, experimental data for the wave height produced from two different pumps is shown. The two pumps are identical, except that the first has a 2-bladed rotor, and the second has a 4-bladed rotor. Both pumps operate with the same working fluid. The attached data shows that for the particular solder used and the given fixed geometry of the rotor, the 4-bladed pump provided a larger wave height than a 2-bladed rotor for a given RPM, particularly at the lower RPM. For larger RPMs, the results show little advantage in using multiple vanes from the perspective of efficiency.

In EXHIBIT B are shown transient characteristics of two pumps. The two pumps are

identical, and pump identical working fluids, except that the first pump has a single-bladed rotor, while the second has a 4-bladed rotor. The effects of step increases in RPM are shown on the undulations produced. These figures show that when the rotational speed of the pump was instantaneously changed, the wave height for the four-blade pump stabilized at a new height much more rapidly than did the wave height for the single-blade pump. I do not consider this result to be predictable, since I do not know of any characteristic of screw pumps which would necessarily result in this phenomenon.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

Charles Garris, Jr.

Date: August 17, 2010

Exhibit A

Comparison of 4-blade pump and 2-blade pump

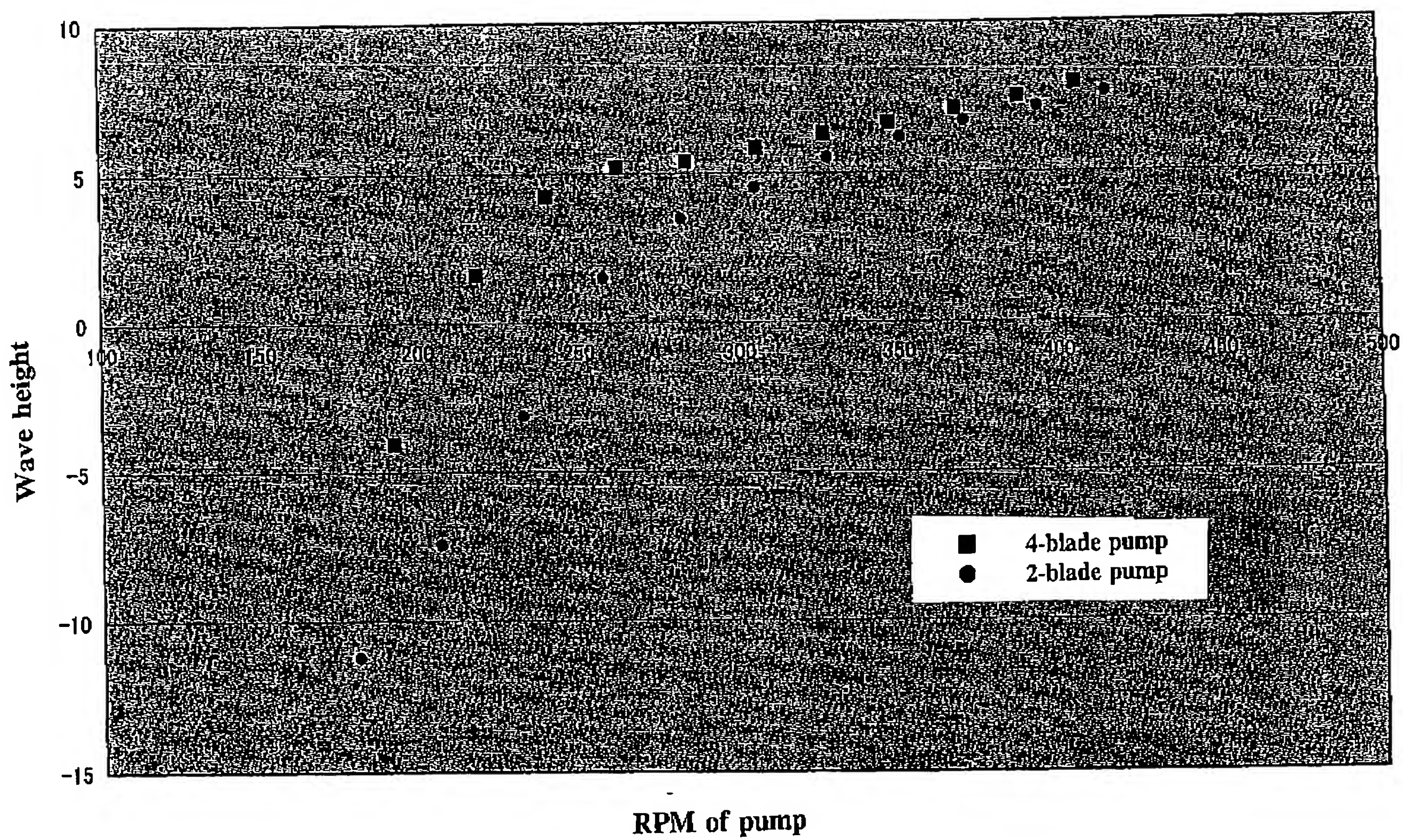

Exhibit B, page 1 1-blade spiral screw

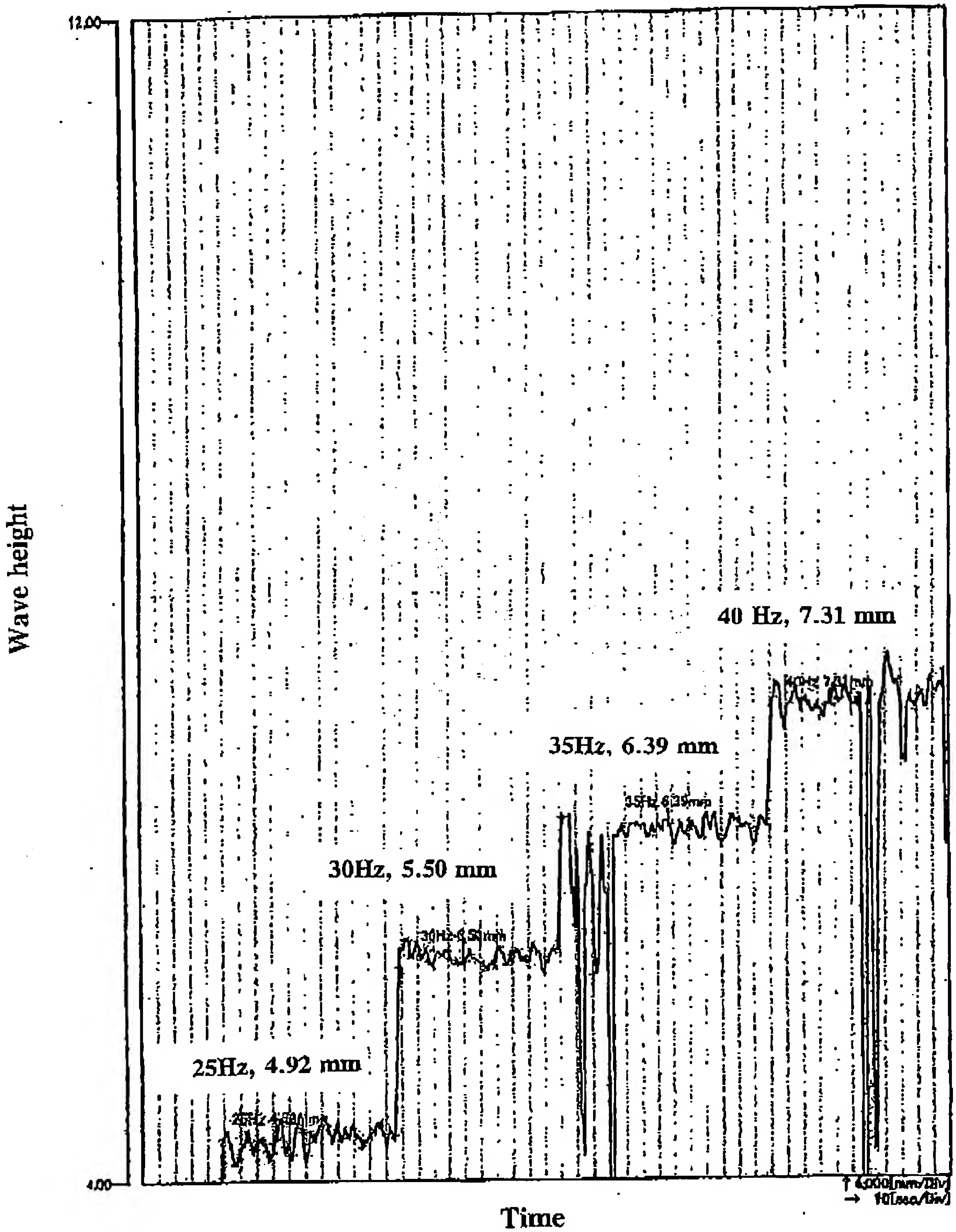

Exhibit B, page 2 4-blade spiral screw